Co-operation / Synergy

Between Waste Management & Storage Sectors:

Setting up the Roadmap

Presented By Andrew Helps

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An Image Problem

- The Fundamental issue with Mercury Management is that Mercury does not smell, does not make your eyes weep, is tasteless and invisible in many of its forms

- Even in developed countries, death or disablement from exposure to mercury is rarely, if ever, diagnosed or investigated

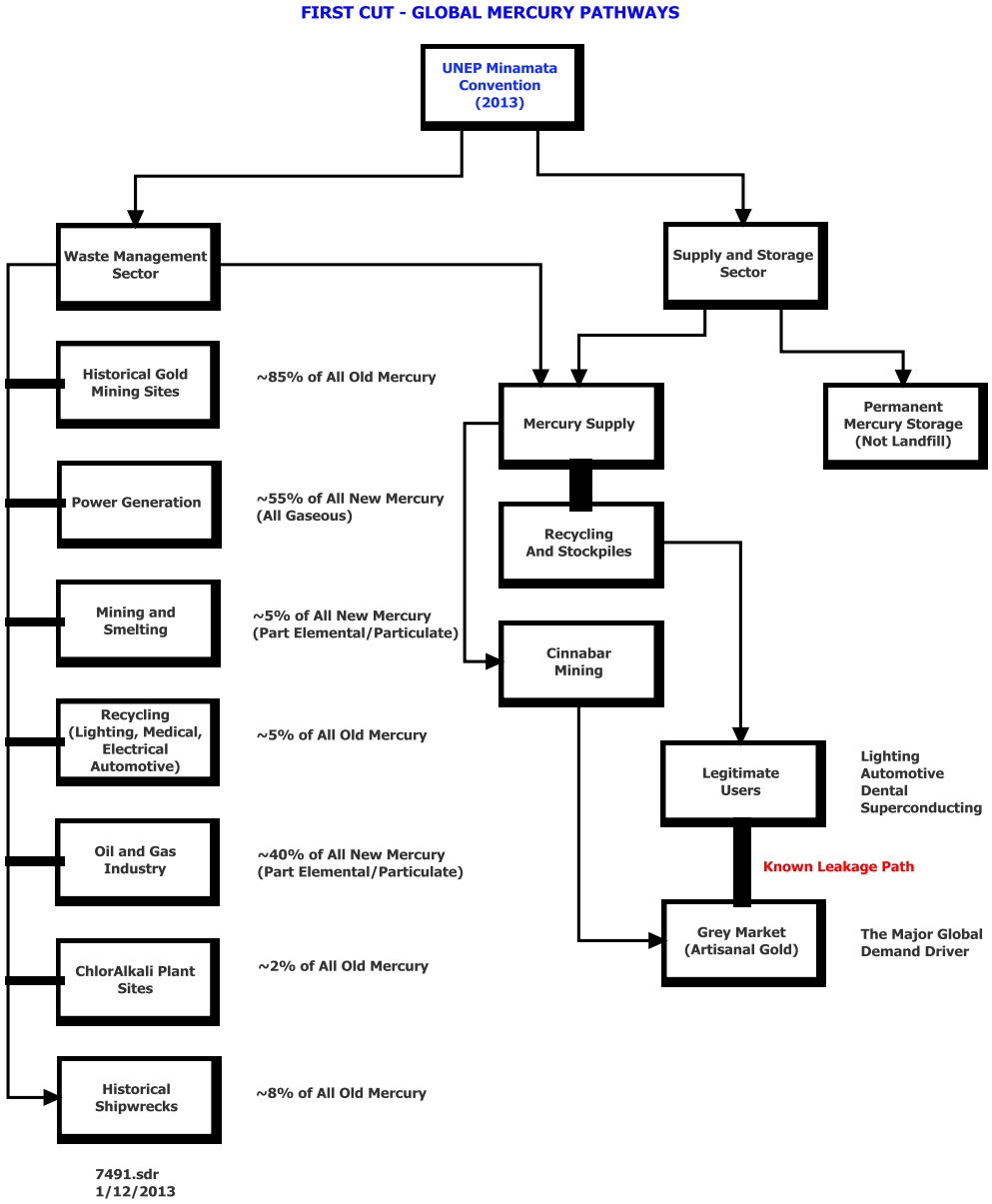
- If mercury had an acrid pungent smell and the gaseous forms created crimson red clouds then its removal from the environment would be a total focus of all governments, globally

Inventory ?

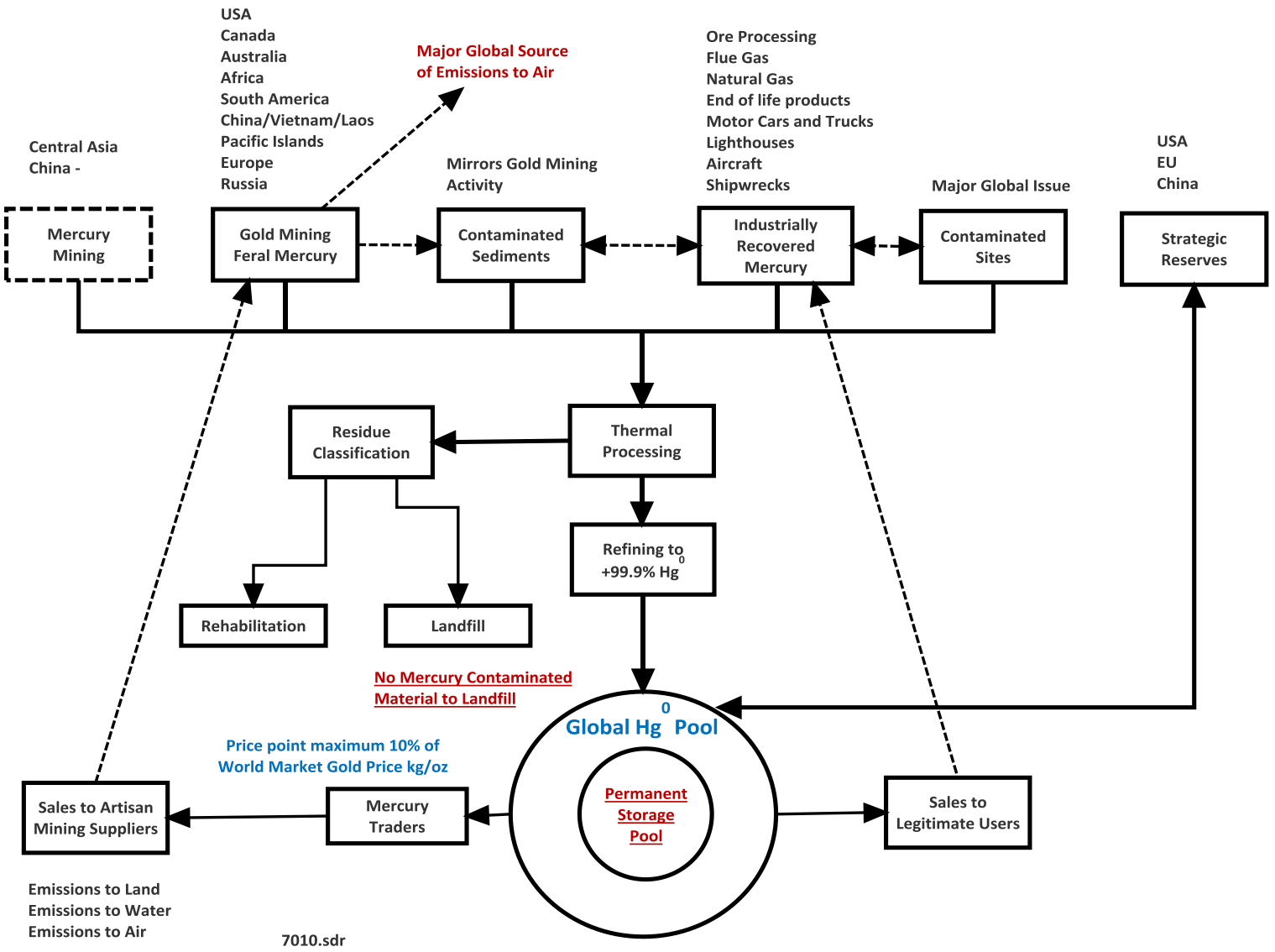
- There is no accurate Global Mercury Inventory to provide the hard data required to deliver a meaningful response or even to prioritise the responses to the Minamata Convention

- Contaminated sites are a global issue and are also an intergenerational issue

- There are key lessons to be learned from the inventory models developed for Carbon Dioxide Management


FIRST CUT - GLOBAL MERCURY PATHWAYS
UNEP Minamata Convention (2013)
Waste Management Sector
Supply and Storage Sector
Historical Gold Mining Sites
~85% of All Old Mercury
Power Generation
~55% of All New Mercury (All Gaseous)
Mining and Smelting
~5% of All New Mercury (Part Elemental/Particulate)
Recycling (Lighting, Medical, Electrical Automotive)
~5% of All Old Mercury
Oil and Gas Industry
~40% of All New Mercury (Part Elemental/Particulate)
ChlorAlkali Plant Sites
~2% of All Old Mercury
Historical Shipwrecks
~8% of All Old Mercury
Mercury Supply
Permanent Mercury Storage (Not Landfill)
Recycling And Stockpiles
Cinnabar Mining
Legitimate Users
Lighting
Automotive
Dental
Superconducting
Known Leakage Path
Grey Market (Artisanal Gold)
The Major Global Demand Driver
7491.sdr
1/12/2013

GLOBAL MERCURY PROCESS + CYCLES



Three Sources

- Basically three core mercury pollution sources:
  - Mining: Gold Mining, Cinnabar Mining, Smelting
  - Power production from coal and fuel oil
  - Industry: electrical products, pesticide and fungicide production, ChlorAlkali plants, VCM Plants, paints and coatings
- Most Countries/States have at least one of these sources; many have all three

Sector Rationalization

Key Issues:

1. Hg supply to Artisanal Mining Sectors;
2. Identification of legitimate users;
3. Volume of Hg required by legitimate users;
4. Where will Hg be sourced from;
5. Location of permanent storage facilities;
6. Maintenance and overheads for storage;
7. Where is the education of next generation of bureaucrats to come from?

The Overwhelming Issue

- Supply of mercury to the artisanal mining sector for a sufficient period to allow alternative gold recovery technology to be developed and implemented.

Recent Research

1. The Wholesale value of mercury used by Artisanal Sector is at least $US 390 million per year;
2. The actual price paid by miners can be up to four times this figure;
3. Returns to miners from the sale of gold is often less than 50% of the ruling price;
4. Cost of mercury to the Artisanal Miner for recovery of a gram of gold is at least 80 US cents Equivalent;
5. Currently a gram of gold is $US Eq 39;
6. The Artisanal Miner is getting between $US 15-20 per gram;

Recent Research

7. Our Preliminary Work indicates the Global Artisanal Sector is using about 3980 tons of mercury per year.
8. On current pricing this sector is producing around $US Eq 38.5 billion worth of gold.
9. Mercury pricing going forward will not impact the Artisanal Sector – the miner in the field is currently paying over $US Eq 400 per Kg for Hg and could pay twice this amount with little impact.
10. Between 50% and 80% mass of mercury is used one time only

Mercury Mining

- Mercury mining is the major uncontrolled variable in the mercury supply chain
- Most major historical cinnabar mines have been shut down or heavily curtailed in their operations
- This control of historical suppliers has created the situation where smaller mines in less politically stable areas have been re-opened with little, if any, environmental controls
- This is now a highly profitable business with the International market presently running at $US 110+ kg

Shipwrecks

- An urgent need to identify historical shipwrecks which contained mercury as ballast/cargoes
- Generally wrecks from the 1830's to 1930 with bulk of the wrecks in the period 1840 to 1890.
- No data on historical exports of mercury from China to mines in the Pacific Basin
- A major pollution source for the marine food chain

Co-operation /Synergy

- Our recent research indicates that small and medium scale Cinnabar Mines may well continue to operate as the rewards are so large;
- Developing mechanisms to better understand the global mercury supply mechanisms;
- Development of alternative cheap and effective gold recovery technology

Mercury in Mining

- Artisanal mining is the biggest consumer of mercury, globally
- Artisanal mining creates the biggest risk to human health and the environment
- There is ‘clear evidence’ of legally exported dental amalgam mercury being diverted to artisanal mining
- There exists a critical need to provide artisanal miners with cheap effective retorting equipment

Historical Gold Mining

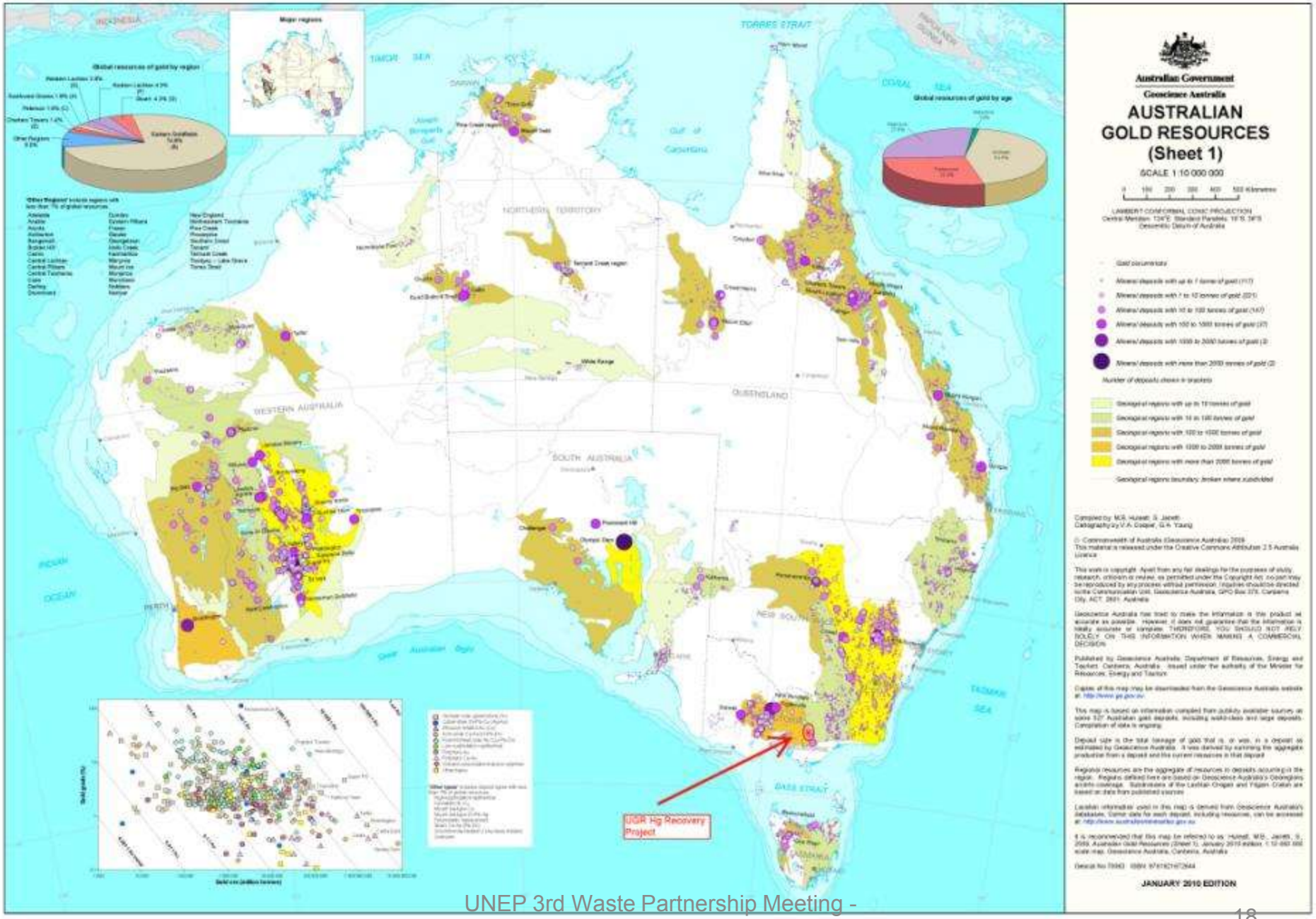
- Over 3000 years of mercury use in amalgamation for fine gold and silver
- Over 3000 years of Cinnabar Mining to produce this mercury
- On a single use basis, at least 50% of the mercury used was lost to the environment
- **This is the major global source of gaseous and environmental mercury to this time**
- **This is the major global raw material for environmental production of methyl mercury**

Australian Case Study

- 470+ Historical Gold Mining Areas across Australia
- 33% of the entire Australian landmass was subjected to all forms of gold mining activities
- Mercury was used and lost on all Goldfields!

Mercury in Australian Soils

- Pre-gold mining levels were in the range of 2-4 ng/M^2 (2-4 x 10^{-9}g/$M^{2)}$
- Post-gold mining levels (circa mid-1970's post Hg usage) could be as high as 80 mg/M^2, or 20-40 million times the 'pre-gold mining level; a 10^7 times increase across the entire Australian continental land surface

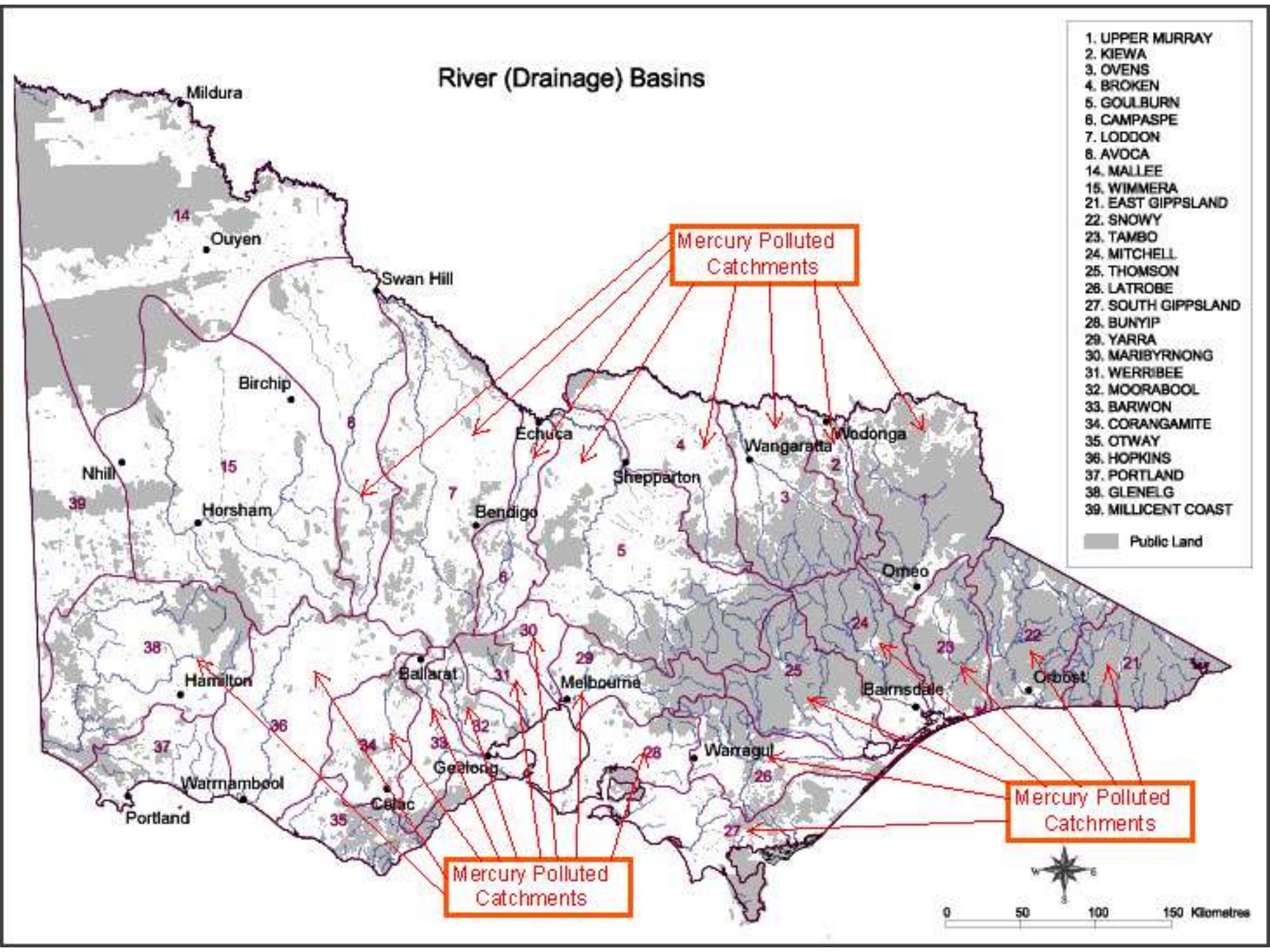

Australian Government
Geoscience Australia
AUSTRALIAN GOLD RESOURCES (Sheet 1)
SCALE 1:10 000 000
LAMBERT CONFORMAL CONIC PROJECTION
Geodetic Datum of Australia
Global resources of gold by region
Global resources of gold by age
Major regions
TORRES STRAIT
TIMOR SEA
CORAL SEA
NORTHERN TERRITORY
QUEENSLAND
WESTERN AUSTRALIA
SOUTH AUSTRALIA
NEW SOUTH WALES
INDIAN OCEAN
BASS STRAIT
TASMAN SEA
UGR Hg Recovery Project
JANUARY 2010 EDITION

Where is it now?

- Some of the mercury will still be close to where it was lost or is contained within ore crusher fines piles and their associated waterways
- Some of this mercury will have evaporated and been transported by the wind for short to long distances.
- Mercury vapor transported by the wind can condense and enter soil systems when conditions are favorable.
- By this method areas that only had background levels of mercury and no historical gold mining activity can become seriously contaminated

Hg Recoveries Pty Ltd
Liddell's Sands Bendigo - Preliminary Field Survey Data
File 7499xlsx

Site #	Date	GPS Coordinates South	GPS Coordinates East	Hg	As	Pb	Cr	Co	Cu	Zn	Mn	Ag	Sr	Ca	P	K	S	Ti	Fe	Cl	Se	Rb	Ba	Zr	Mo	Sn	Cd	Sb	V	Bi
1	8/09/2012	36° 44.959'	144° 14.420'	112	12,921	625	83	108	157	4,569	413	ND	48	3,982	1,964	8,181	1,881	5,769	289,754	3,045	ND	63	185	296	ND	127	11	153	102	23
	8/09/2012	"	"	100	13,841	577	129	100	161	4,470	409	5	37	4,054	254	7,579	1,596	6,803	327,491	3,636	ND	46	186	610	ND	165	7	157	98	47
	8/09/2012	"	"	45	14,494	788	118	92	151	4,689	438	6	56	5,215	ND	8,500	1,393	6,829	319,996	3,089	ND	54	179	470	ND	345	7	151	113	47
	8/09/2012	"	"	105	16,040	703	87	111	178	5,527	476	2	47	4,667	ND	8,084	1,347	7,215	326,982	3,261	ND	56	160	511	ND	201	11	126	126	16
	8/09/2012	"	"	89	12,357	663	120	107	148	4,098	428	3	50	4,101	ND	8,402	829	6,133	310,704	3,521	ND	56	182	390	ND	590	6	124	102	38
	8/09/2012	"	"	89	13,362	686	143	82	148	4,145	365	2	40	4,088	ND	8,802	2,977	7,106	300,184	3,596	ND	54	221	601	ND	458	6	131	112	32
				90	**13,836**	**674**	**113**	**100**	**157**	**4,583**	**422**	**3**	**46**	**4,351**	**370**	**8,125**	**1,529**	**6,643**	**312,519**	**3,358**	**0**	**55**	**186**	**480**	**0**	**314**	**8**	**140**	**109**	**34**
2	8/09/2012	36° 44.951'	144° 14.418'	76	5,993	2,302	115	53	103	1,873	331	2	153	7,553	ND	8,965	1,673	4,190	150,426	1,736	ND	54	429	125	1	37	3	38	90	ND
	8/09/2012	"	"	76	6,524	2,015	98	82	122	1,955	307	1	310	6,565	ND	8,647	1,225	4,152	215,466	2,830	ND	48	326	241	2	128	7	37	97	ND
	8/09/2012	"	"	75	7,960	2,191	90	69	117	1,555	300	6	152	6,205	ND	8,732	1,425	4,420	203,475	2,526	ND	49	271	384	ND	65	6	37	87	ND
	8/09/2012	"	"	60	7,035	1,981	84	61	97	1,748	313	3	237	6,605	ND	8,454	2,034	4,670	174,616	2,155	ND	46	313	226	ND	104	4	36	105	ND
	8/09/2012	"	"	77	8,897	1,726	65	77	123	1,792	287	2	124	6,065	ND	8,823	1,794	4,003	222,359	2,273	ND	49	295	264	ND	60	4	30	109	ND
				73	**7,282**	**2,043**	**90**	**68**	**112**	**1,785**	**308**	**3**	**195**	**6,599**	**0**	**8,724**	**1,630**	**4,287**	**193,308**	**2,304**	**0**	**49**	**327**	**248**	**1**	**79**	**5**	**36**	**98**	**0**
3	8/09/2012	36° 44.951'	144° 14.420'	51	2,248	165	52	16	33	883	373	2	111	28,194	ND	9,099	740	2,741	53,437	877	ND	34	173	127	1	24	3	1	70	ND
	8/09/2012	"	"	38	2,178	124	50	23	40	958	532	2	101	30,868	ND	9,204	1,914	2,489	57,636	877	ND	33	205	131	ND	22	3	3	71	ND
	8/09/2012	"	"	51	2,297	124	44	19	31	1,034	433	1	99	30,929	ND	9,056	449	2,427	54,398	785	ND	35	169	99	ND	12	2	16	62	ND
	8/09/2012	"	"	43	2,232	138	46	12	23	738	386	2	105	26,736	ND	8,645	1,087	2,339	41,498	811	ND	37	154	82	2	15	3	7	68	ND
	8/09/2012	"	"	30	2,187	163	52	15	40	1,072	365	2	94	28,377	ND	8,907	1,466	2,824	49,079	757	ND	40	175	113	1	28	2	9	67	ND
				43	**2,228**	**143**	**49**	**17**	**33**	**937**	**419**	**2**	**102**	**29,021**	**0**	**8,982**	**1,131**	**2,556**	**51,210**	**821**	**0**	**36**	**176**	**110**	**1**	**20**	**3**	**7**	**68**	**0**
4	8/09/2012	36° 44.945'	144° 14.437'	51	6,516	748	122	160	254	1,210	380	13	80	25,957	ND	3,719	1,048	7,157	624,374	5,153	ND	50	58	593	ND	3	ND	35	97	204
	8/09/2012	"	"	79	5,710	778	232	165	250	1,152	353	14	69	24,971	ND	3,405	1,769	8,061	658,412	6,131	ND	43	120	604	ND	3	2	33	124	236
	8/09/2012	"	"	68	5,896	738	177	160	245	1,165	356	11	67	25,308	ND	3,824	ND	8,128	627,935	5,355	ND	51	112	630	ND	ND	2	27	114	210
	8/09/2012	"	"	78	6,630	777	166	163	261	1,243	435	14	72	27,700	ND	3,611	1,032	9,557	651,707	5,613	ND	50	125	668	ND	10	ND	32	100	251
	8/09/2012	"	"	63	5,978	768	194	161	253	1,163	427	13	69	26,038	ND	3,319	2,000	8,891	667,366	6,030	ND	56	143	669	ND	5	6	29	123	229
				68	**6,150**	**762**	**178**	**162**	**253**	**1,187**	**390**	**13**	**71**	**25,999**	**0**	**3,576**	**1,170**	**8,359**	**645,999**	**5,656**	**0**	**50**	**112**	**633**	**0**	**4**	**2**	**31**	**112**	**226**
5	8/09/2012	36° 44.948'	144° 14.452'	109	12,097	850	169	199	351	1,148	597	9	71	17,810	ND	6,493	2,930	10,355	652,339	5,388	ND	59	198	1,070	ND	6	1	117	182	224
	8/09/2012	"	"	107	13,173	948	164	189	342	1,146	558	14	79	18,120	1,761	6,821	2,015	10,755	649,438	6,106	ND	57	179	1,250	ND	6	ND	155	158	237
	8/09/2012	"	"	70	12,244	769	153	167	301	1,141	576	12	72	17,761	386	7,359	4,340	8,692	591,352	5,812	ND	38	219	651	ND	3	3	125	136	198
	8/09/2012	"	"	92	13,367	874	188	174	334	1,177	548	14	73	18,173	ND	6,814	1,257	9,857	654,618	5,923	ND	63	204	1,014	ND	7	2	96	168	241
	8/09/2012	"	"	62	12,290	836	151	178	338	1,160	558	10	71	16,796	ND	6,815	957	9,080	625,873	5,760	ND	60	199	1,018	ND	2	ND	86	136	229
				88	**12,634**	**855**	**165**	**181**	**333**	**1,154**	**567**	**12**	**73**	**17,732**	**429**	**6,861**	**2,304**	**9,748**	**634,728**	**5,798**	**0**	**59**	**200**	**1,001**	**0**	**5**	**1**	**116**	**160**	**226**
6	8/09/2012	36° 44.919'	144° 14.447'	50	7,668	774	127	148	260	925	572	7	53	9,407	ND	6,442	ND	8,118	587,290	5,869	ND	60	216	340	ND	8	ND	27	158	244
	8/09/2012	"	"	58	8,550	831	113	157	244	973	516	7	54	9,322	ND	6,518	206	7,756	584,889	5,427	ND	55	289	440	ND	10	2	29	142	181
	8/09/2012	"	"	47	8,825	825	168	139	294	938	557	7	49	9,878	ND	6,591	1,771	6,830	578,080	5,652	ND	52	278	429	ND	6	6	40	154	213
	8/09/2012	"	"	60	8,122	825	96	152	297	945	488	8	49	8,647	ND	6,632	685	8,397	618,926	5,410	ND	55	273	431	ND	6	4	37	156	237
	8/09/2012	"	"	57	8,108	839	120	164	294	958	541	9	48	9,462	ND	6,448	2,331	8,144	612,840	5,583	ND	64	358	351	ND	5	1	38	151	220
				54	**8,255**	**819**	**125**	**152**	**278**	**948**	**535**	**8**	**51**	**9,343**	**0**	**6,526**	**999**	**7,849**	**596,389**	**5,588**	**0**	**57**	**283**	**398**	**0**	**7**	**3**	**34**	**152**	**219**
7	8/09/2012	36° 44.905'	144° 14.536'	135	7,808	1,254	99	87	235	610	522	4	77	5,384	500	8,220	333	3,797	414,166	5,614	ND	49	195	389	1	5	1	37	118	135
	8/09/2012	"	"	116	7,357	1,333	135	65	212	560	512	5	143	5,827	ND	7,926	1,550	4,486	395,607	5,640	ND	71	270	336	ND	7	4	39	123	115
	8/09/2012	"	"	90	7,198	1,233	108	64	212	604	490	4	122	5,333	406	7,452	2,251	3,974	398,660	5,392	ND	56	182	244	0	ND	2	38	139	114
	8/09/2012	"	"	104	7,295	1,211	108	74	236	564	504	4	115	4,997	ND	7,711	ND	3,993	429,966	5,728	ND	60	256	350	ND	16	4	38	115	150
	8/09/2012	"	"	109	6,944	1,258	117	66	211	543	489	4	116	5,713	286	7,414	1,016	3,906	387,371	5,591	ND	57	234	393	ND	ND	3	37	107	116
				111	**7,320**	**1,258**	**113**	**71**	**221**	**576**	**503**	**4**	**115**	**5,451**	**238**	**7,745**	**1,030**	**4,031**	**405,214**	**5,593**	**0**	**59**	**227**	**326**	**0**	**6**	**3**	**38**	**124**	**126**


River (Drainage) Basins
1. UPPER MURRAY
2. KIEWA
3. OVENS
4. BROKEN
5. GOULBURN
6. CAMPASPE
7. LODDON
8. AVOCA
14. MALLEE
15. WIMMERA
21. EAST GIPPSLAND
22. SNOWY
23. TAMBO
24. MITCHELL
25. THOMSON
26. LATROBE
27. SOUTH GIPPSLAND
28. BUNYIP
29. YARRA
30. MARIBYRNONG
31. WERRIBEE
32. MOORABOOL
33. BARWON
34. CORANGAMITE
35. OTWAY
36. HOPKINS
37. PORTLAND
38. GLENELG
39. MILLICENT COAST
Public Land
Mercury Polluted Catchments
Mercury Polluted Catchments
Mercury Polluted Catchments
Mildura
Ouyen
Swan Hill
Birchip
Nhill
Horsham
Echuca
Shepparton
Bendigo
Wangaratta
Wodonga
Omeo
Hamilton
Ballarat
Melbourne
Bairnsdale
Orbost
Warragul
Geelong
Warrnambool
Portland
Colac
0 50 100 150 Kilometres

How is Mercury Lost

- Gold ore crushing plants used mercury in their stamp beds and recovery tables to amalgamate gold.
- Mercury was exposed to air and evaporated as the crushing process took place.
- The gold recovery bed was covered with running water and mercury was washed out of the final recovery trap attached to fine rock particles and ended up in the environment.

How is Mercury Lost - 2

- Mercury was used by artisan miners working in rivers and streams to amalgamate gold – mercury was lost by evaporation and also washed into rivers and streams via inefficient recovery processes
- Mercury was used in the riffle boxes in all sluicing and dredging operations.
- Mercury was used in all dry blowing (no water available) operations to amalgamate gold and silver particles

How is Mercury Lost - 3

- Mercury was lost when gold amalgam was intentionally heated to evaporate the mercury and recover the contained gold (called dore).
- Mercury poisoning was the biggest unidentified cause of preventable death on all goldfields

ChlorAlkali Plants

- Gradually being phased out due to environmental impacts and high cost of top up mercury
- These plants generated massive profits especially during the period 1930 to 1990.
- By far the most intensive mercury polluters
- Plants often made mercury based pesticides / fungicides and a plethora of organochlorine based chemicals

ChlorAlkali Plants

- The locations of many “remediated” plants have not been properly “remediated”
- Site clean up costs invariably exceed the capital base of the site owner – therefore these sites become an intergenerational legacy issue for a government
- Sites commonly have a large range of toxic metals and chemicals complicating clean up and creating risks from offgassing

EDUCATION

- With the advent of the Minamata Convention there will be an urgent need to create at least two “Centres of Excellence” to provide the training for the tens of thousands of people that will be required at a Country and State Level to implement the Targets and Goals of the Convention.
- Generally the ‘teachers - trainers’ for these people are extremely limited, globally

EDUCATION

- People who have worked on mercury issues since the 1960's and 1970's are all approaching or are already in retirement
- People with operational experience of mercury based gold crushing equipment are very few, very old and often have cognitive problems caused from their working environment
- People who have operated mercury based ChlorAlkali Plants or VCM plants are still about but most have cognitive problems to different degrees caused from their work

EDUCATION

- In the area of historical gold mine assessment there are very few people globally who have done this work and almost all of these are within Government
- In the area of mercury rehabilitation project costing including analytical field XRF work the number of people with required “T-Shape” Skill Sets AND who have done this type of work, is probably less than 10 globally, and they are all now well into their 60’s

EDUCATION

- ***Governments will be looking for excuses not to adopt the convention*** and the major excuse will be the lack of key technical skills to carry out the analyses to determine the extent of mercury risks in their area of control

- The Minamata Convention Secretariat MUST focus on preserving these existing skills and in establishing the required "centres of excellence" as a very urgent priority.

EDUCATION

- Without a clearly defined career path for young scientists and engineers in the mercury remediation industry the fundamental goals of the Minamata Convention will most likely not be met

- It is critical that the current knowledge of the very few people experienced in scoping and costing mercury remediation projects be passed down onto the generation of people who will be tasked with delivering the Minamata Convention in practice, into the future.

GETTING IT RIGHT

- The UNEP Mercury Waste Management Partnership must take the lead role to make sure that Educational Resources are in place to deliver to the next generation of Scientists and Engineers the necessary training to oversee the removal of mercury from the global environment, over the next 30 years